

DOCUMENT RESUME

ED 175 727

SE 028 810

AUTHOR Brown, Mark; And Others
TITLE How Things Work. Teacher's Guide.
INSTITUTION Florida Audubon Society, Maitland.
SPONS AGENCY Office of Education (DHEW), Washington, D.C. Office
of Environmental Education.
PUB DATE 75
GRANT G007407881
NOTE 29p.; For related documents, see SE 028 807-809
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Earth Science; *Ecology; Elementary Secondary
Education; *Energy; Environment; *Environmental
Education; *Environmental Influences; Pollution;
*Science Education
IDENTIFIERS Energy Education; Florida

ABSTRACT

This unit examines the earth's processes and systems from an energy perspective. A technical language for discussion of energy systems is developed. Objectives include the ability of students to discuss earth's carbon/oxygen cycle, hydrological cycle, and heat patterns and the functioning of producers, consumers and decomposers in the environment. Students will also be able to describe simple environmental concepts and predict consequences of changes in the environment. (Author/RE)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

74-7881

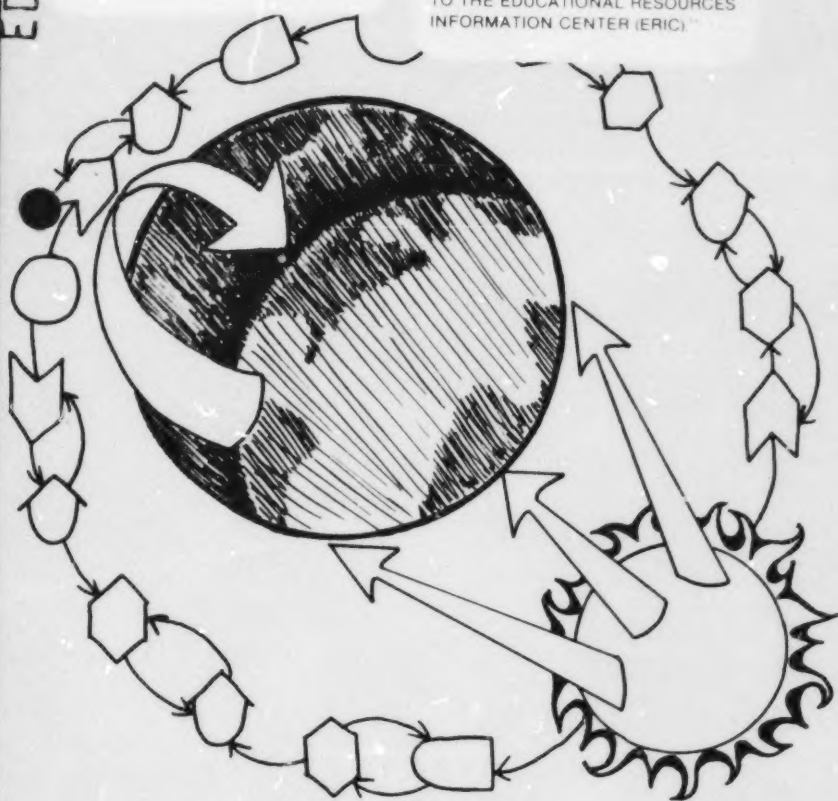
U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY

Walter Bogan

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC).



How Things Work

ED175727

SE 028810

The project reported herein was performed pursuant to a grant from the U.S. Office of Education, Department of Health, Education and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of the U.S. Office of Education, and no official endorsement by the U.S. Office of Education should be inferred.

The materials in these programs were written and compiled during 1974-75 under a grant awarded to the Florida Audubon Society by the Department of Health, Education, and Welfare, Office of Technology and Environmental Education, Washington, D.C. 20202.

Information concerning this publication and program may be obtained from:

Florida Audubon Society
Division of Environmental Education
921 Lake Sybelia Drive
Post Office Drawer #7
Maitland, FL 32751



"... I think what's going to have to be done in the next three or four years is for everyone, but especially for the students who are just entering the world, to re-evaluate the whole position in this country that we're facing in regard to what we do for money and what money will buy and what money won't buy."

"... What we're going to have to do is to change the patterns of consumption in this country and in the rest of the world. The same thing is true of energy... we're going to have to think in terms of energy units instead of in terms of money..."

"... So we have to learn something new, and it's going to be rough."

Margaret Mead
Boston, 1975



ACKNOWLEDGMENTS

This program was made possible through a grant from the Division of Technology and Environmental Education, Office of Education, United States Department of Health, Education and Welfare.

This program was developed by the Florida Audubon Society.

Major contributors in this were:

Mark Brown---Associate Professor, Environmental Engineering, University of Florida
Gainesville, Florida

Carla Palmer---Director, Environmental Education,
Florida Audubon Society
Maitland, Florida

Alan R. Sandler---Environmental Education Consultant,
Environmental Education Inc.
Tampa, Florida

Merlien Wilder King---Freelance Commercial Artist
Apopka, Florida

Nancy Rudland---Clerical Technician
Orlando, Florida

Photographic Assistance was provided by:

Walter J. Kenner, Helen Cruickshank, Ken Alvarez, James Carmichael, Chip Demarest; U.S.D.I. Everglades National Park, Peter Pritchard, Bill Partington, Roy McDiarmid, Tim O'Keefe, Charles Lee, Jim Thomas, Mark Brown, Alan Sandler, Carla Palmer, E. Mullison.
All photographs are scenes taken in Florida's cities, farms and wilderness.

CONTENTS

HOW THINGS WORK

Quote by Margaret Mead
Acknowledgements

Introduction	5-6
Overview	7-11
The teacher...	13
Objectives and Concepts	14
Script	15-26
Activities	27
Supplemental Aids	28

I. INTRODUCTION

Each of us is a part of the environment. We affect the environment and it affects us. A safe, healthy environment is essential for our existence. Yet, we have caused serious changes about us. We have brought about an environment that soon may no longer meet our requirements for survival. We must examine ourselves in order to understand what has caused these environmental changes.

Early man's effects upon his environment were minimal. His role was one of participating in environmental changes as they happened, rather than causing them to take place. He found food, water, and shelter more by chance than by design. He was extremely dependent upon nature, barely managing to eke out an existence from his surroundings. Primitive man still has this role, but modern man has progressed far beyond a humble dependence upon what his environment happens to be or what happens to take place within it.

Modern man is able to cause profound changes in his environment. In this he is unique. All other species have been limited to the effects they could cause by the force of their own bodies. But modern man, through the use of his intellect and technology, has multiplied the effect of his body many times over. Using these effects, he has changed the environment-- the land, the air, the water, and the living things of earth. Some of these changes have been beneficial, many have been harmful.

INTRODUCTION (cont.)

Now man the changer must find ways to maintain an environment suitable for himself and all other living things. Only recently has man realized his responsibility for maintaining a healthful environment. The serious environmental problems we are facing today demonstrate the impact modern man has had upon the environment.

We have the intelligence and ability to meet the crisis of the environment. To solve this crisis, we will need to re-educate ourselves about our responsibilities to nature. We hope that this program will aid in that re-education.

II. OVERVIEW

This program is designed to help students to understand their environment. In this program, students are encouraged to explore their environment from an energy systems approach. Earth's processes and systems are examined in terms of energy flows. The students consider the complex workings of "spaceship earth" and become aware of the effects modern man is having on it.

Students, however, differ in their ability to learn. They differ from region to region, from age level to age level, and from class to class. Moreover, no one student learns equally well in all modes of instruction. The components of this program have been designed to overcome such disparities of learning.

In this program, students use a variety of instructional modes and media. By hearing, seeing, feeling, and doing the students become involved in a variety of learning experiences.

The various components of this program are readily adapted to the different modes of instruction commonly used today by students in their learning activities. Using these components for individualizing instruction, a student can work alone and progress at his own rate. These materials may also be used by students in small groups of three or four as they stimulate one another's thinking, exchange thoughts, and discover ideas. In some cases, the students may choose to work with the materials in large groups. The program is designed to allow

OVERVIEW (cont.)

and to encourage such flexibility in its use.

MAJOR OBJECTIVES

There are three major objectives to be achieved through student involvement in this program.

- 1--- The students will discover basic information and understand basic concepts about environmental systems and will demonstrate their comprehension by appropriately applying the concepts in activities.
- 2--- The students will be able to identify major environmental problems, will be concerned about these problems, and will be able to discuss some ways these problems can be resolved.
- 3--- The students will demonstrate a personal commitment by taking actions which will aid in the prevention or solution of environmental problems they observe.

PROGRAM STRUCTURE

The materials included in this program are open-ended in the development of content and concepts. In their use of these materials, the students are offered a wide range of options for further development of information and ideas and for the application of what they find.

The program "Your Florida Environment" consists of three modules:

Module #1 --- "How Things Work"

An exploration of Earth processes and systems from an energy point of view. Energese, the energy system language used throughout the program, is explained.

OVERVIEW (cont.)

Module #2 ---- "Florida's Urban Environment"

Beginning with the historical development of Florida from an energy systems approach, this program deals with the urbanization process in Florida and explores where it is leading.

Module #3--- "Endangered Species"

An examination of the causes of the endangerment of Florida's plant and animals species with a detailed look at Florida's varied ecological systems. A view of the complexity of the balance of nature and this relationship to man.

Each module contains one sound-filmstrip and a Teachers Guide. The sound-filmstrip is designed to operate either manually or automatically by cassette tape player and filmstrip projector.

The subject matter developed in these materials is appropriate for students from cities, suburbs, or rural areas. These materials are directed at students from grades 5 and above.

OVERVIEW (cont.)

ENERGETICS LANGUAGE

The "Your Florida Environment" programs use a pictorial language that symbolized systems relationships. This language, *Energese*,** is used to describe the complex processes and systems involved in understanding the environment. The symbols used in this language are:



ENERGY SOURCE symbol represents a source of energy from outside the system such as the sun, fossil fuel, the water from a reservoir, or iron ore from the ground.



ENERGY STORAGE symbol (tank shape) shows the location in a system for storage. Examples are a grocery store, into which potatoes are moved and later removed, or a fuel storage tank. Some work must be done by some other unit in order to move the energy in and out of the storage.



INTERACTION symbol shows the coming together of two or more energy sources needed within a process in order to produce the result. An example is the interaction of the farmer's labor, sunshine, fertilizer, soil, etc., to produce a crop.



a) THE PATHWAY symbol is used to indicate the flow of energy from one part of the system to another part.



b) THE DASHED PATHWAY symbol is reserved to show the flow of money.

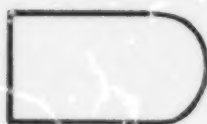


THE PRICE symbol shows that within man's system there is usually a flow of money to pay for the energy. An example is the exchange of money in a grocery store for the food that we buy.

OVERVIEW (cont.)



THE HEAT-SINK symbol. Heat, the random thermal motion of molecules is the ultimate fate of all energy. As energy flows through any system it becomes degraded, i.e., it loses the ability to do further work. Three different examples of the way in which energy degrades are: (1) the loss of energy due to friction (2) the natural depreciation that occurs when any energy is stored (3) the consumption of energy in order to run or process any type of energy interaction.



THE PRODUCTION symbol represents a self-maintaining production population, such as trees and grass. It also contains storages and interactions and has input energy such as sunshine combining with raw materials to produce a useful output such as trees. While production unit is normally associated with plant operations, it can also be used with any production process that contains a cycling, self-limiting material flow.



THE CONSUMER symbol represents a self-maintaining consumer population, such as deer or the residential sectors of our own society. Within it are combinations of storages and interaction units.

** Energy Crisis to Steady State, H.T. Odum

MODULE #1 "HOW THINGS WORK"

The teacher is a very important factor in the success of any program. This part of the guide contains ideas for the use of this module that can help you obtain maximum student participation with a high level of achievement. These ideas, guidelines, observations, activities, and practical suggestions are offered for your use. Any approach or teaching pattern offered is not intended to show you the way to use the program. As the teacher, you will develop many ideas and approaches to suit your style of teaching and to fit the learning patterns of your students. Use whatever works best for you and your students.

MODULE #1 "HOW THINGS WORK"

OBJECTIVES :

Students will be able to discuss the earth's carbon/oxygen cycle , hydrological cycle, and heat patterns. They will be aware of the functions of the producers, consumers, and decomposers in our biosphere. They will be able to use energetics language to describe simple environmental concepts and to predict the consequences of changes in the environment.

CONCEPTS DEVELOPED :

All earth energy originates with the sun.

There is a carbon/oxygen cycle in the biosphere.

The hydrologic cycle is powered by heat in the biosphere.

Weather systems are powered by heat in the biosphere.

There is an interdependence of earth systems.

Energetics language can be used to describe systems.

There is an interdependency between the earth's producers, consumers, and decomposers.

Ecological energy principles govern man and nature.

- (1) How Things Work
 - (2) Produced by the Florida Audubon Society.
 - (3) Energy is the basis, source and necessity for all life.
 - (4) People and animals use the energy found in food.
 - (5) Plants use the energy from the sun and make food.
Any process...either living or non-living...uses energy.
 - (6) Industrial plants use energy from fossil fuels.
 - (7) Automobile engines use energy from oil.
 - (8) Houses use energy from electricity.
 - (9) Whole cities use energy from a variety of sources... sunlight,
fossil fuels, food, water, wind, rain, air, and soil.
- All processes are the interaction of energies to do useful work.
- All the different kinds of work processes are called systems.
A system is a collection of individual, interacting elements
that combine to use energy and do useful work.
- (10) People are systems of interacting parts such as bones, internal
organs, skin and muscles that use energy to do useful work.
 - (11) Automobiles are systems that have collections of such things
as engines, tires, windows and lights that combine to use
energy and do useful work.
 - (12) The house is a system.
 - (13) The neighborhood is a system.
 - (14) Cities are systems where people, buildings, automobiles and
roads collectively use energy to do useful work.
 - (15) Florida is a system.
 - (16) The United States is a system.
 - (17) The earth is a system.
 - (18) Either real or imaginary boundaries can be formed around
a system. The outside walls of a house could be called its
boundary.

- (19) The lines dividing countries on a map are invisible boundaries.
- (20) A person's skin is the boundary of his body.
- (21) And a boundary defines the limit of the system. Anything inside the boundary is a part of the system, and anything outside the boundary is not. Anything that crosses the boundary from outside to inside is an energy source to the system.
- (22) The only source of energy for the earth is sunlight. The machinery or systems of the earth run on sunlight. All the processes of earth derive their energy from sunlight.
- (23) View our planet from outer space as the astronauts and high flying satellites do to see how all the systems within systems work and how they are related.
- (24) To discover the building blocks of life we searched among the microscopic parts of things.
- (25) To discover how the earth works and how all its systems use energy we will rise above, step back, simplify the complex, see large patterns... Take a macroscopic view of our planet.
- (26) Earth....A machine whirling in space covered by a thin water and air shell powered by the sun's radiant energy. The driving force for all the earth's engines.
- (27) One engine is the production engine. When the sun shines on the green plants of the earth, tons of oxygen are released and the plants store food.
- (28) Then in the shadows of dusk the oxygen is taken in by the plants to burn the food produced during the day. Carbon dioxide, water vapor, and heat are exhaled by the plants at night. We call this process respiration.
- (29) About half of the energy that comes to the earth from the sun does not drive the production engine but is absorbed in the materials of the earth's surface, becoming heat. The energy of sunlight heats the seas, especially in the tropics, and causes the earth to be heated unevenly. Between the hotter and the cooler zones a giant heat engine operates developing...

- (30) wind systems and evaporating waters which circulate over the land and polar regions. Rains and snows drop the water back to the land, where it returns by river and glacier to the sea.
- (31) The earth's heat engine contributes to the production engine by bringing raw materials such as rain and minerals more rapidly to the plants. The plants in turn transpire water that goes back to the heat engine currents.
- (32) Ocean currents, driven by the uneven heating of the waters move minerals and organic matter of the seas and often concentrate them. Here large amounts of aquatic life can be found.
- (33) We can now see that these two earth engines... the production engine and the heat engine are interrelated and dependent on the proper functioning of the other.

There are systems which function to maintain the earth's engines. Energetics is a language used to describe what is happening in systems. We will use energetics to help us understand the workings of the systems within the earth's engines.

- (34) The primary producers, or plants of the earth are found on land and in the seas. We already know that plants use sunlight, water and carbon dioxide to make oxygen, a little heat and an organic substance called sugar. The bullet shape represents producers in the system. The circle is the energy source from outside the system, in this case the sun. The line and arrow going from the energy source to the producer represents the flow of energy. The lines drawn downward to the ground represents the heat given off by the producer.
- (35) Other organisms in the system need and use the energy locked in the form of sugar in the plants. So they consume the plant in order to live, grow and produce offspring.
- (36) The hexagon describes consumers in a system. The line drawn from the producer to the consumer represents the energy flow. Heat is given off by the consumers.
- (37) The primary consumers are unable to use all the plants that they eat and deposit what is left over. The plants deposit old plant matter. All of these are then consumed by the microorganisms and decomposed into their basic elements.
- (38) These decomposers are also represented by a hexagon. Energy

is seen to flow from the consumers and the plants to the decomposers. Heat is given off.

- (39) Now the consumer performs a vital and necessary service to the plant community. First it has to do some work to get the plants. By eating some of the plants the consumer has provided a way for more new plants to grow. This work done by the consumer actually increases plant production. The line drawn from consumer to producer shows this energy flow.

The arrow shaped block pointing into the plant community shows that two types of energy are interacting to pump energy into the plants faster than it would flow normally, for the consumer is helping the plants to grow better.

- (40) The decomposers perform a similar function for the plants. Whatever is left over by the consumers is an energy source for the decomposers. They break down this matter into basic minerals and elements which can then serve as nutrients or energy for the plants. An energy flow line is drawn from decomposer to producer and another pump is added, for the nutrients interact with energy from the sun and consumers to help the plant community grow better.
- (41) In this system each member performs a valuable service for the other members and for the system as a whole. If we remove all of one member, such as the decomposers, the entire system dies, for nutrients are an essential energy source for the plant's system.
- (42) The system also works for its parts. We have seen how the production engine of the earth acted to help drive the heat engines. The heat engines in turn drive the weather systems, and the weather systems bring life-giving rain to the production engine. So the Producer-Consumer-Decomposer system is a necessary condition for the well being of the entire biosphere and the biosphere is necessary for the Producer-Consumer-Decomposers.

We have observed some basic principles by which all systems operate.

- (43) The law of energy conservation says that the concentrated energy entering a system must equal the dilute energy flowing out of the system.
- (44) Ultimately all the energy that comes to the earth from the sun each day leaves in the form of invisible heat radiation.

- (45) All systems need energy to function. This energy is used to build and maintain order. Things that are ordered are concentrated and arranged.
- (46) The flow of energy through the biosphere is continually helping the building of order by arranging patterns from the disordered raw materials. A system grows or builds order until its energy inflows balance outflows.
- (47) The energy degradation law states that in all work processes some of the energy loses its ability to do work and is degraded in quality. Degraded energy leaves the system primarily as heat and waste products.
- (48) The law of energy degradation also takes into account depreciation. We have learned that energy can build order. Depreciation is that process of things becoming disordered.
- (49) The maximum power principle states that the system that survives in competition with other systems is the one that gets the most energy and uses it most effectively to insure a continually increasing flow of energy into the system.
- (50) A system will use all the energy that is available to it by building mechanisms and structure to help get more energy. The more energy it gets the more mechanisms and structure it can build to go after even larger amounts of energy.
- (51) The four energy principles require that any unit that survives in the world of systems and sub-systems have energy coming in balancing with the energy going out.
- (52) It must use its incoming energy to build structure and feed back some energy to gain more energy.
- (53) Through this process it must pay the necessary price of doing work and degrade some of the energy into waste products and dispersed heat.

Everything in the biosphere...including man...is governed by these laws.

We can use these energy principles to better understand and manage ecosystems.

- (54) Let's look at a microcosm, a replica of an ecosystem, using our energy principles. Consider a small aquatic microcosm or fish tank. Our tank has five fish and some

plants for them to eat and it is balanced... In steady state. That is the population will stay at a maximum of five fish. One or two may die, but new ones will be born to replace them.

- (55) Energetically our fish tank system looks like this. The only energy source from outside the system is sunlight. The plants make sugar and oxygen from the sunlight and the carbon dioxide and other minerals in the water. The fish eat the plants and breathe the dissolved oxygen. The waste products from the fish are carbon dioxide, organic matter which falls to the bottom of the tank, and heat. The organic matter is decomposed by microorganisms and made into elements for the plants to use.
- (56) If we add fish food to the aquarium, we will be increasing the energy available to the animals. This would raise the carrying capacity of the aquarium. The carrying capacity is the population level the tank can support. The carrying capacity of the tank was five fish. So let's suppose that we add enough food to raise the carrying capacity to ten fish.
- (57) If we maintain this added amount day in and day out the fish will multiply and we may have a new steady state. With our increased number of fish there will be increased amounts of wastes. This in turn will allow the population of decomposers to grow. Now we have the capability of increasing the nutrient supply to the plants, and they in turn will grow. As the tank becomes more crowded, the waste from the fish plus some dying leaves from the plants will fall to the bottom and begin to build up. If the population of decomposers grows large enough to demand all the oxygen in the water to do their job of decomposing the wastes, then the fish will die from lack of oxygen.
- (58) But what would happen if we saw that growth in the tank was getting out of hand and wanted to do something about it? We could withdraw our input of fish food. In time the number of fish would drop back to five, some of the plants would die and we could have a balanced aquarium once more.

Our microcosm, as well as all other ecosystems behave according to the four energy laws.

- (59) The fish used some energy to build structure and maintain order in their bodies so that they could get more food.
- (60) Animals and plants grew old and died and others came along to take their place.
- (61) As the energy supply to the tank increased the system took full advantage of it and grew structure...
- (62) until it reached the limit that the energy supply would support.

The same principles that apply to our plant and animal systems apply to the people systems.

- (63) Our society has evolved to require two sources of energy. They are the dilute energies of nature such as sunlight, wind, rain, tides, and waves; and the concentrated energies of nature in the form of coal, oil, and natural gas. We shall refer to these concentrated energies as fossil fuels because of the way they were made by the earth.
- (64) Until recently the energy that people had for their use was increasing. The large storages of energy buried millions of years ago were pumped or dug from the ground and used to run the machinery of our farms and cities.
- (65) Without realizing it directly we employed the maximum power principle which says that the system will survive if it uses some of its energy to bring in more energy to be used toward meeting its needs for survival.
- (66) With increasing amounts of fossil fuel available to us we built cities,
- (67) agricultural industries, populations, factories, schools,...
- (68) ...All to help bring in more energy.
- (69) Note the energy available to our city systems.
- (70) As the flow of energy into the city increases the size and complexity of the city increases. We know that the energy flowing into the system must equal the stored energy plus the degraded energy flowing out of the system.
- (1) So as the energy flow increases into the city we can also expect to notice heat and waste products flowing out of the city.

- (72) Heat is generated from machines of transportation, industry and power plants and make the city hotter than its surrounding countryside.
- (73) Particles of inorganic substances and gases are expelled into the air.
- (74) Garbage, old cars and trash are discarded.
- (75) Liquid wastes in the forms of sewage and chemicals are poured into surrounding ecosystems. Also as the energy increases, disorder increases. Machinery wears out, buildings need repair, our social systems may need updating.

The energy laws can be used to gain insight and solutions to many of the problems facing us today.

- (76) One of these problems is pollution.

Pollution is too much energy in any one place.

Some call it waste, but what is waste to one system... is fuel or energy to another.

- (77) Sewage is a source of energy to an ecosystem and is used by its plants and animals. If the flow of sewage increases, the amount of energy available to the ecosystem increases. We know that a system will grow structure and order to maximally use the energy source for its survival. So with sewage as a seemingly limitless energy supply from the cities the organisms in our ecosystem grow rapidly.

- (78) Algae and water hyacinths abound. Fish have plenty to eat. Other animals thrive on the plants and fish.

From our experience with our aquarium, we know that if sewage continues to flow into our ecosystem faster than the system can assimilate it we can anticipate that the oxygen will be used by the decomposers and many of the fish will die. So as the sewage continues to flow in, adding more organic fuel to the system, the predominant plant and animal life will be those which can use the energy to their best advantage.. algae and bacteria.

- (79) Many birds and other animals will stop coming to this place for food and water. People may say that this system is dead, but it is not really dead. It is culturally eutrophic... rich in algae and bacteria. Pollution then is a word we choose

to mean too much energy in one place at one time.

- (80) Many of Florida's lakes are naturally eutrophic. They are energy rich and are evolving toward becoming another ecosystem. Over thousands of years organic substances build up on the bottoms of lakes until they are filled. They then become prairie systems. But in Florida it has taken only 20 years for many lakes to become culturally eutrophic.
 - (81) Another great concern is the energy crisis and how it will effect our systems of economics and energy use.
 - (82) Until recently we thought that there was no end to the concentrated forms of nature's energy available to us.
 - (83) We invented systems to use the energy, to feed it back to gain additional energy which built bigger cities, larger machines, faster cars.
 - (84) All things that used more energy. Through this process we have created a higher standard of living which in energy terms just means that we have invented faster ways of using energy.
 - (85) The use of ever increasing amounts of energy has allowed us to raise the carrying capacity of our environment. By growing more food per acre through the use of fossil fuels, fertilizers, and energy expensive irrigation systems, and by reducing our wastes through the use of energy expensive pollution control devices we have increased the density of populations that can live off our lands.
 - (86) We know that fossil fuel deposits are getting harder and harder to find, and we must dig deeper and go farther away from home to find the energy to run our machines and systems. One of our energy principles states that every time we go after some energy we have to spend some energy as work to get it. The harder energy is to find the more we have to expend to get it.
 - (87) Net energy is the energy left after the costs of exploration, extraction, production, and transportation are subtracted from the gross yield. So today with increased costs of obtaining oil we are getting less and less energy return as time goes by.
- In effect our fossil fuel is running out even though there is still plenty left in the earth.

This is a hypothetical energy diagram to show the concept of net energy.

Although we are drawing ten gallons of oil from a well, it takes an equivalent of nine gallons to extract it because of the location and depth of the well, and the equipment needed. Our net yield is only one gallon of oil.

- (88) So the energy available to our systems may in fact be decreasing. We know that systems grow or decrease in proportion to the availability of the energy source.
- (89) This decreasing net yield of fossil fuels may mean that our systems will become less energy intensive, that we would have smaller cities, less cars, smaller farms, less inventions to use energy.
- (90) Also the carrying capacity of our environment would decrease. Another of our energy laws tells us that structure in systems always depreciates or tends to disorder. A steady supply of energy is needed just to maintain order and structure. With a decreasing energy supply we can expect the ratio of order to disorder to increase.
- (91) We notice that we cannot build more order, and the order we have created in the past continues to degrade. So we expect buildings to run down, roads to go unrepaired, social services to decay.
- (92) In our systems of cities and agriculture we rely on two sources of energy: the dilute and the concentrated. Our dilute energy is constant and our concentrated forms may be decreasing. Our systems of cities, transportation, and agriculture may degrade and disorder. We may no longer be able to maintain the very complex highly energy intensive systems we have. In the future we can expect our systems to decline, but they will not completely vanish. We will still have our constant dilute sources. Our system will adjust to fit our energy supply.
- (93) But what would happen if our energy sources were unlimited, if some new power source replaced our fossil fuels? If this happens, according to our energy laws our systems would build structure to maximally use the energy. Our cities would grow, populations would increase, and industry would gear up to use the energy.

But another energy law tells us that the energy going into the system must equal the energy ultimately coming out of the system.

- (94) Things will still depreciate. But there will be enough energy to make replacements. Cities will be hotter. There will be even more energy going into the surrounding ecosystems, and causing pollution. With a limitless supply of concentrated energy we may be able to even compensate for this ecosystem loss. For instance, if the city were putting too much heat into the system,...
- (95) we could air-condition more or enclose entire cities in giant domes. We could use machines to cleanse water and air, blow pollutants from our cities, stir the oceans, and control the weather systems. We would have to use concentrated energy to do the work that nature is doing for free. We would invent machines to monitor and control the natural systems. We would raise the carrying capacity of our environment. As the systems of people would grow and get more complex we would have to develop larger systems to control the complexity. In essence, all systems of man and nature would have to be controlled so that order could be ..
- (96) maintained.
- (97) Today we are putting massive amounts of technology into the development of new energy sources. Preliminary studies show that some may replace fossil fuels,
- (98) but none as yet promise to give us an unlimited, easy to obtain energy source. Therefore, until an unlimited source is discovered, we must live with the fact that our energy sources are decreasing in availability.
- (99) Those systems that survive in the future will be the ones that maximize the available energy sources. These systems will develop storages of high quality energy which will help them increase inflows from outside the system. We may see nations going to war to obtain energy.
- (100) Information is the highest quality energy. Should our concentrated energies continue to decline we must use them as well as information to learn to maximize the dilute forms of energies which nature provides for free.
- (101) We will go back to the land for our way of life, and society will develop in small agricultural communities. We will have to

work to maintain the stability of the system.

- (102) We must be adaptable to changes. We must be able to work in many skills and use these skills to make the system work. We will rely on each other more and machines less.
- (103) We will have to conserve our natural resources to make sensible transitions to the new systems. The best of our technology would be used with thrift. We will rely on nature to help us more.
- (104) We must develop a better understanding of the individual because of the increasing importance for us to be able to work in groups and as nations to manage our remaining energy reserves.
- (105) Are you ready for the challenge, the change, the excitement and the hope of the future ?
- (106) This program was made possible.....
- (107) The End

MODULE #1 "HOW THINGS WORK"

ACTIVITIES :

Describe a local environmental problem energetically.

What are the energy sources?

Who are the producers, consumers, decomposers?

Where are the storages, the feedback loops, the heat sinks ?

After looking at the problem energetically, suggest solution alternatives.

Describe each energetically and then decide which set of alternatives best solves the problem.

How does the fish tank experiment correlate to the world hunger problem?

Why is there a world hunger problem? What should be done about it ?

Construct a microcosm using animals other than fish and an atmosphere other than water. Describe it energetically.

How does energy flow through your school ? Are there any feedbacks ?

Is your school successful in competition with other schools ? Why?

What can you do to make your school more successful ?

What alternatives do you see for careers in the future given that there will be a decreasingly available concentrated energy supply ?

MODULE # 1 "HOW THINGS WORK"

SUPPLEMENTAL AIDS:

Selection of material for this section does not constitute official endorsement or approval of it by the Florida Audubon Society, or the United States Office of Education to the exclusion of others which may be suitable.

Environment, Power, and Society, Howard T. Odum, Wiley-Interscience, New York

This book offers a macroscopic view of man and his part in the delicate balance of forces that sustains life in the biosphere. To analyze man made and natural forces, the author discusses the common denominator that unifies these seemingly disparate energetic processes--- power.

Natural energy such as solar radiation, the hydrologic cycling of the oceans, or the cyclic exchange of carbon, hydrogen, oxygen and nitrogen can be easily diagramed in terms of power. But the author shows that the affairs of man also have quantitative power ratings and that the important issues of man's existence and survival are as fully regulated by the laws of energetics as those of the physical and chemical world.

Energy Crisis to Steady State, Howard T. Odum, McGraw-Hill

This book is designed as a text for high school and junior college students to introduce them to energy systems language. It deals with the concept of systems, explains the energy principles, relationships of energy and growth, energy and money. The book shows how these principles are applied to all systems from individual organisms to nations and the world.

The book ends with an analysis of what the future holds for man as we begin a new era of limited energy and thus a steady state, no growth way of life.

"Energy, Ecology, and Economics", Howard T. Odum, ENFO Newsletter, The Environmental Information Center of the Florida Conservation Foundation, Inc., Winter Park, FL.

In this paper Dr. Odum reports to the Royal Swedish Academy of Sciences his theories of net energy and steady state economic and foreign policy.